Scientific requirements and dimensioning for the MICADO-SCAO RTC

Global overview of the instrument

- Shown in ‘stand-alone’ phase.
- Same mount structure as when under MAORY.

Design spaces:

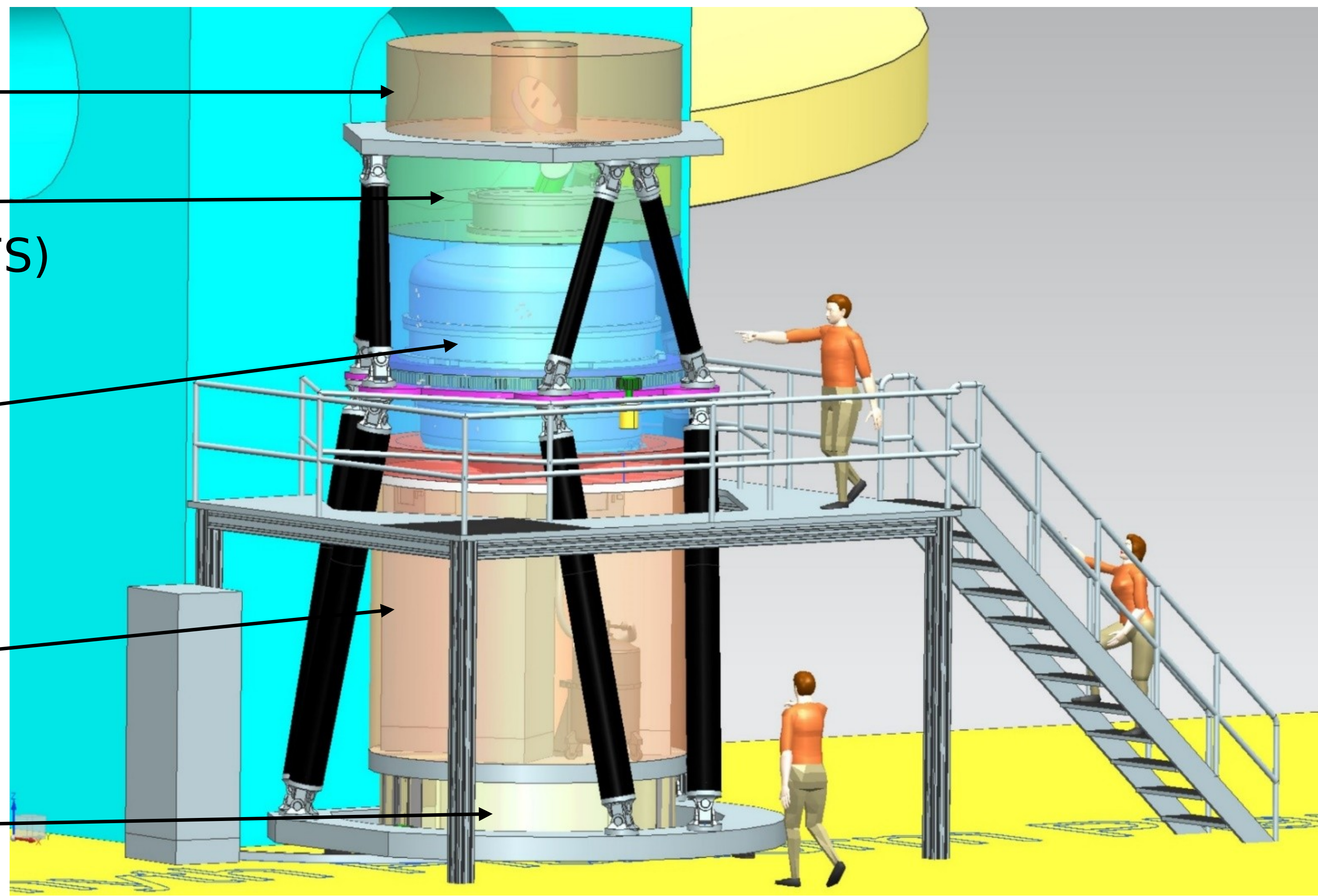
Fold mirror & calibration unit

SCAO (+ MAORY NGS-WFS)

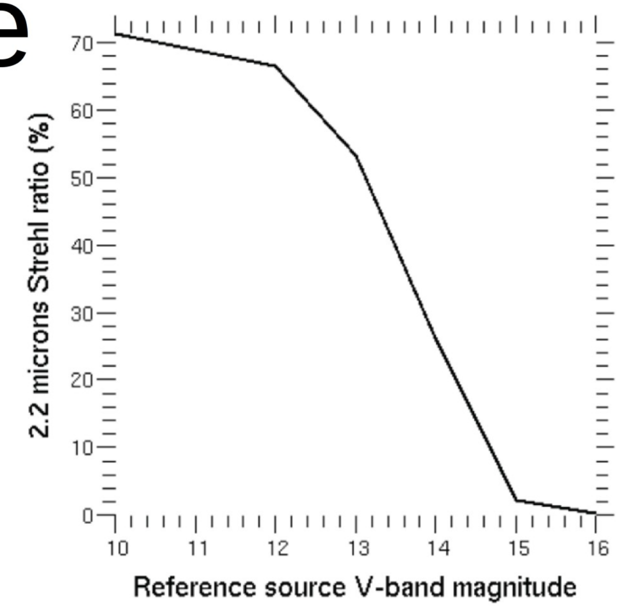
Cryostat & derotator

Electronics (co-rotating)

Cable-wrap



SCAO performance



Based on end-to-end GPU simulations

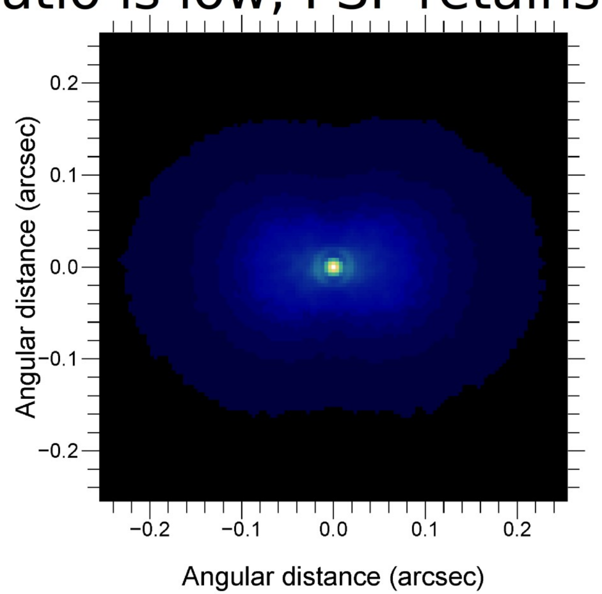
Maximum strehl

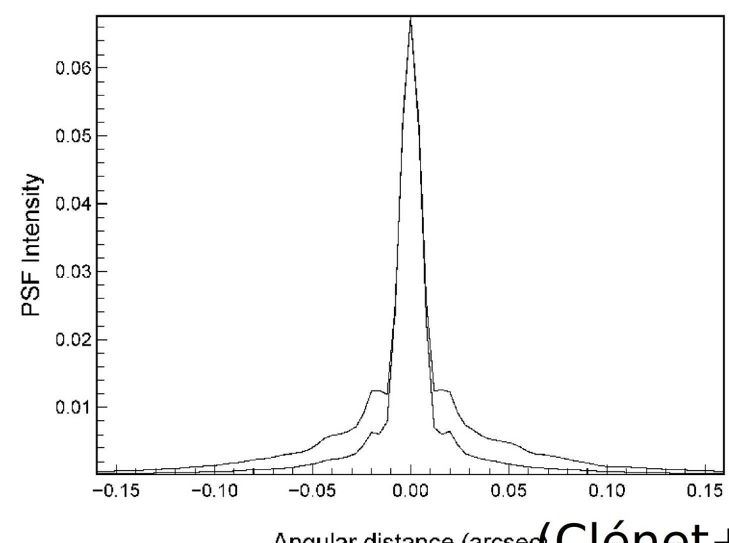
- Limited by M4 and telescope WFE budget
- Residual tip-tilt ~3mas

Anisoplanatism

- Different to 8-m telescopes, because E-ELT diameter is comparable to L_0.
- Although strehl ratio is low, PSF retains a diffraction limited core even far off-axis

PSF with radial & transverse cuts, 30” off-axis, for realistic L_0 profile (K-band Strehl ~6%)





(Clénet+ 13, 14)

MICADO SCAO in few numbers

- MICADO-SCAO
  - Framerate : 1000Hz
  - 1 SH WFS :
    - 840x840 pixels @1kHz ~11.3Gb/s
    - 80x80 ssp, let say ~10k measurements
  - 1 DM : ~5k commands
  - Command matrix : ~50Mb

MICADO-SCAO RTC

- Hard real-time subsystem:
  - Baseline, linear control with matrix-vector multiply
  - MVM Performance : 100 Gflops
  - Determinism : 10% jitter over a 1000 FPS framerate : 100µs requirement
  - Technology trade off study : CPU / GPU / FPGA
- Supervision module : optimization of hard-real time parameters
  - Main task : regular control matrix update
  - SVD Performance : 750Gflop (but memory-bound)
  - Addressed with a standard HPC cluster

GPU Compute performance

- For the computation part, 1 GPU is enough :

Model	Architecture	Theoretical peak performance single precision (TFLOPS)	Memory bandwidth (Gb/s)	ECC	Energy consumption (W)
NVidia Tesla K40	Kepler	4.29	2304	Yes	235
NVidia Tesla K80	Kepler	8.5	3840	Yes	300
NVidia M6000	Maxwell	6.07	2539	No	222

- But, MVM is a io bound problem, the memory bandwidth the first performance indicator.

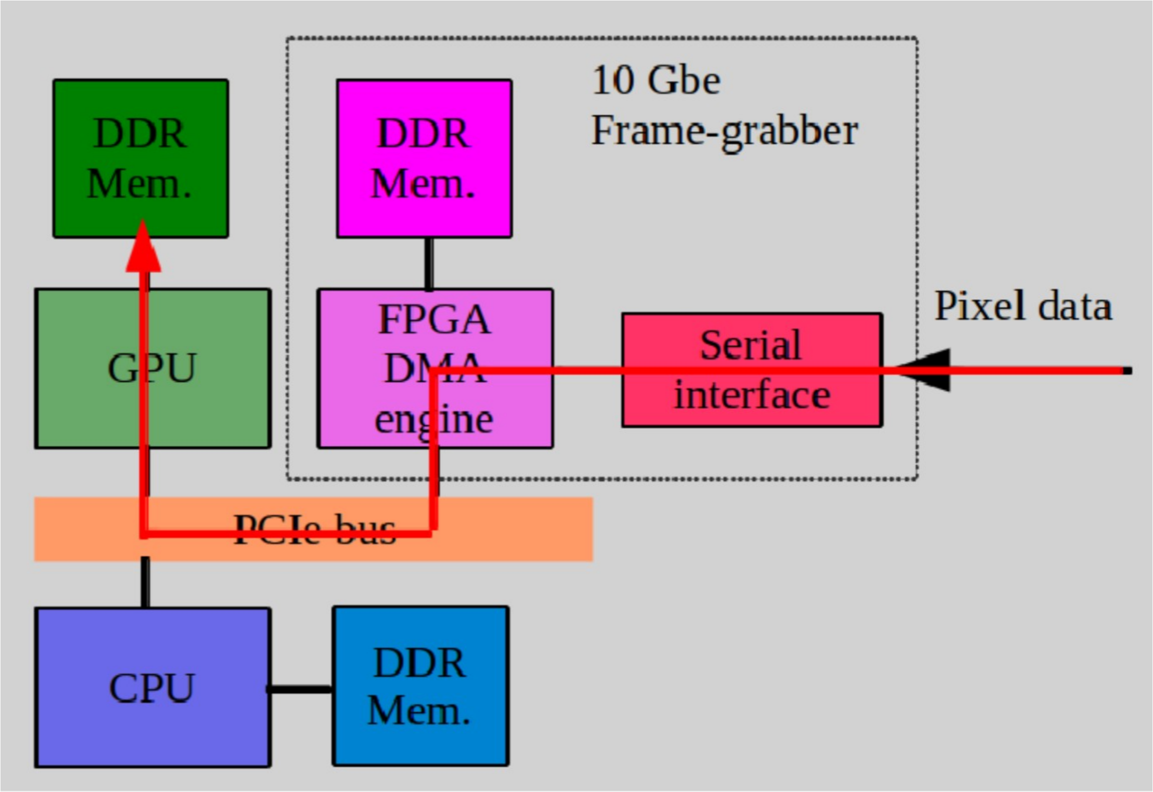
	K20C	K40	K80	M6000
B theo	1664	2304	1920 (x2)	2539
B ECC off	1400 (84%)	1888 (82%)	1536 (x2, 80%)	1968 (77%)
B ECC on	1200 (72%)	1664 (72%)	1360 (x2, 70%)	NONE

  - NGPU = CEIL(CR / (B * FPP)) = 2 GPUs K40

    *100 Gflops / (1880 Mb/s * 32) = 1.7*

GPU Compute performance

- Need for tailored data acquisition process



- See Denis Perret & Julien Bernard presentations tomorrow

CPU Compute performance

- Intel Xeon CPU / Xeon Phi
  - Between 100 & 280 GB/s memory bandwidth per processing units
  - Up to 5 CPUs or 2 Xeon Phis (see David Barr presentation tomorrow)
- Reference solution using standard libraries and portable code
- Need vectorization on Xeon Phi to meet peak performance
- Long term availability of Xeon Phis questionable

FPGA Compute performance

- ARRIA 10AS066 SoC
  - 1.5GHz ARM dual-core Cortex-A9 co-processor
  - 1855 DSP blocks
  - 5.2MB int. RAM
  - max. 48 XCVR links
- ARRIA 10AX115
  - 1518 DSP blocks
  - 6.6MB int. RAM
  - max. 96 XCVR
- 40 GMAC/s peak performance (80 GFLOP/s)
  - 2 boards are needed to meet performance specifications

ESO specific constraints

- ESO is gathering instrument specifications to build a standardized AO RTC approach (SPARTA evolution ?)
- ESO will define a RTC toolkit for instrument consortia
- Need to take into account E-ELT specificities : e.g. M4 control, handover between telescope control system and AO system …
- Instrument calibration issues : limited daytime slots for instrument calibration may impose efficient strategies with strong computing constraints

Conclusions

- MICADO Preliminary Design Phase has started
- Dimensioning a RTC for the SCAO mode
- Will lead trade off studies for RTC technologies down selection
- Interaction with ESO needed to be compliant with RTC toolkit and design full RTC pipeline including M4 control / interaction with telescope
- Output of Green Flash project (Damien Gratadour presentation) critical for design consideration